

01502512

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

522, 522
 (19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
18 December 2003 (18.12.2003)

PCT

(10) International Publication Number
WO 03/105336 A1

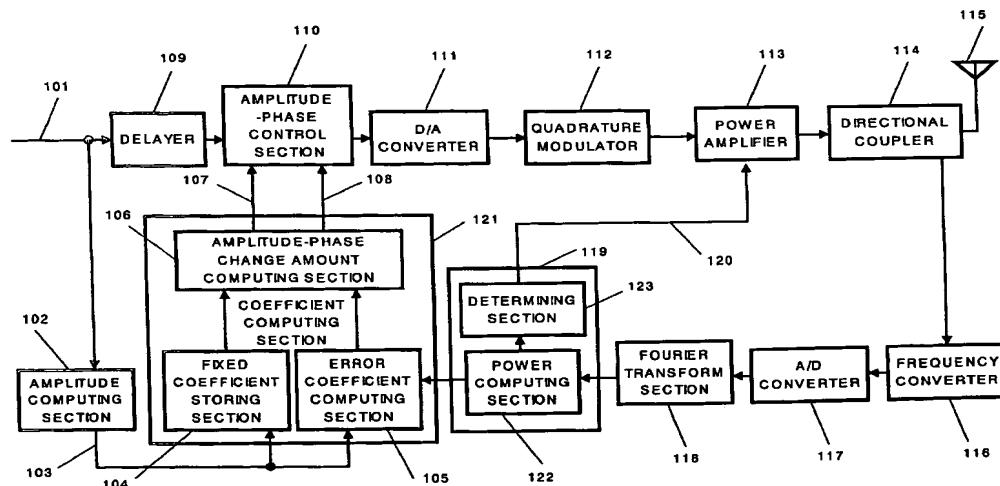
- (51) International Patent Classification⁷: H03F 1/32
- (21) International Application Number: PCT/JP03/07064
- (22) International Filing Date: 4 June 2003 (04.06.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
2002-163950 5 June 2002 (05.06.2002) JP
2003-128756 7 May 2003 (07.05.2003) JP
- (71) Applicant (for all designated States except US): MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD. [JP/JP]; 1006, Oaza Kadoma, Kadoma-shi, Osaka 571-8501 (JP).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): TAKABAYASHI, Shinichiro [JP/JP]; 2-2-17-205, Nobi, Yokosuka-shi, Kanagawa 239-0841 (JP). UKENA, Masato [JP/JP]; 6-2-801, Hikarinoaka, Yokosuka-shi, Kanagawa 239-0847
- (JP). ORIHASHI, Masayuki [JP/JP]; 1-12-1-302, Futamata, Ichikawa-shi, Chiba 272-0001 (JP).
- (74) Agents: IWASHI, Fumio et al.; c/o Matsushita Electric Industrial Co., Ltd., 1006, Oaza Kadoma, Kadoma-shi, Osaka 571-8501 (JP).
- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

[Continued on next page]

(54) Title: DISTORTION COMPENSATOR



WO 03/105336 A1

(57) Abstract: A coefficient computing section (121), for computing a characteristic reverse to an input/output characteristic of the power amplifier (113), is configured by a fixed coefficient storing section (104) and an error coefficient computing section (105). The fixed coefficient storing section (104) is previously stored with the characteristic reverse to a pre-measured input/output characteristic. The error coefficient computing section (105) computes an error coefficient between a characteristic stored in the fixed coefficient storing section (104) and a current characteristic of the power amplifier (113). When the determining section (123) determines that the adjacent-channel leak current power ratio is greater than a predetermined value, an operation halt is instructed to the power amplifier (113). With this structure, rapid convergence is possible in adapting operation for follow-up the characteristic variation of the power amplifier (113). Furthermore, interference to the adjacent channel due to distortion abnormality in the power amplifier (113) can be prevented.

WO 03/105336 A1



— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

10/502512

1

DESCRIPTION

Distortion Compensator

TECHNICAL FIELD

5 The present invention relates to a distortion compensator for compensating a non-linear distortion as caused on a power amplifier used in a radio-communication system's transmitter.

10 BACKGROUND ART

Conventionally, the distortion compensators of this kind include those as described in JP-A-2000-278190. Fig. 5 shows a conventional distortion compensator described in JP-A-2000-278190.

15 In Fig. 5, the data from the data generating section 501 is processed with pre-distortion by a control/operation section 502, that is a DSP, then being sent out through a digital-analog converter 503, an quadrature modulator 504 and a power amplifier 505. A part of the transmission wave 20 is inputted to an quadrature demodulator 507 through a directional coupler 506. An quadrature demodulator 507 demodulates the digital signal and inputs it to the control/operation section 502. The control/operation section 502 compares the amplitude and phase of between a digital signal to send out and a feedback signal obtained by 25 demodulating the sending output of the digital signal, and operation-estimates a distortion over the transmission

circuit and creates a compensation table, according to an LMS scheme or the like. Thus, the transmission digital signal is processed with pre-distortion.

Meanwhile, there are those described in JP-A-10-5 150394, as the conventional distortion compensators that compensate for a non-linear distortion caused on a transmission-system amplifier without using a storage table for storing the compensation coefficient to compensate for a non-linear distortion component. Fig. 6 shows a 10 conventional distortion compensator described in JP-A-10-150394.

In Fig. 6, a power computing section 601 determines a signal power from an inputted quadrature base-band signal. Then, a compensation-coefficient computing section 602 15 computes a distortion compensating coefficient by the use of an approximate equation having that value as a parameter. By using it, a non-linear distortion compensating section 603 compensates for a non-linear distortion. Using an error between an quadrature signal obtained by demodulating an 20 output to which the modulation output is distributed as well as an quadrature base-band signal, a coefficient update section 604 updates the coefficient of the approximate equation.

Furthermore, in order not to send out an abnormal 25 signal from the antenna in the event of a failure of the power amplifier, the conventional distortion compensator is configured to monitor the output power of the power

amplifier. When a power value exceeding a pre-defined value is detected, the power amplifier is ceased in operation.

However, in the conventional configuration disclosed in JP-A-2000-278190, there is a need of large sizes of coefficient tables to express a distortion characteristic of the power amplifier. Furthermore, the frequency of coefficient update is still high, resulting in a problem of time increase before attaining convergence.

Meanwhile, in the conventional structure disclosed in JP-A-10-150394, the quadrature base-band signal to transmit is used as an input to the distortion compensator so that a distortion compensation coefficient is determined by a comparison between this signal and the quadrature base-band signal fed back from the power amplifier output. However, in order to realize the equivalent operation and function where an RF signal is used as an input to a distortion compensator, the RF signal must be down-converted and then subjected to quadrature demodulation, thus involving a problem of complication in configuration.

Furthermore, in the conventional configuration, when abnormality occurs in the distortion amount on the power amplifier in an absent state of abnormality in the output power value, it cannot be coped with by the distortion compensator. Thus, there exists a drawback unable to prevent the interference to the adjacent channel.

It is an object of the present invention to provide a distortion compensator that can reduce the number of times of updating the coefficient for distortion compensation, rapidly converge the adapting operation to follow up the characteristic fluctuation of a power amplifier and prevent the interference to the adjacent channel due to abnormal distortion on the power amplifier.

A distortion compensator of the invention for solving the problem is characterized by configuring a coefficient computing section, by a fixed coefficient storing section and an error coefficient computing section, to compute a characteristic reverse to an input/output characteristic of the power amplifier. The fixed coefficient storing section is previously stored with the characteristic reverse to a pre-measured input/output characteristic. The error coefficient computing section computes an error coefficient between a characteristic stored in the fixed coefficient storing section and a current characteristic of the power amplifier. Because of satisfactorily measuring an error, the number of coefficient updates is reduced as compared to that of a configuration having only a coefficient measuring section.

Meanwhile, when the power amplifier is faulty and the amount of distortion caused is greater than a reference, an out-band power computing section detects that fact and outputs a control signal to the power amplifier, thereby halting the operation of the power amplifier.

Meanwhile, a distortion compensator of the invention comprises: an amplitude phase control section for controlling an amplitude and phase of a transmission base-band signal; an quadrature modulating section for orthogonally modulating an output of the amplitude phase control section; a power amplifier for amplifying an output of the quadrature modulating section; a directional coupler for distributing an output of the power amplifier; a frequency converter for frequency-converting one of outputs of the directional coupler; a Fourier transform section for Fourier-transforming an output of the frequency converter; an out-band power computing section for computing an out-band power from an output of the Fourier transform section; an amplitude computing section for computing an amplitude value of the transmission base-band signal; a coefficient computing section for computing a characteristic reverse to input/output characteristic of the power amplifier on the basis of the amplitude value and notifying the amplitude phase control section of a change amount of amplitude and phase for the transmission base-band signal; a fixed-coefficient storing section for storing a characteristic reverse to a pre-measured input/output characteristic of the power amplifier; an error coefficient computing section for computing an error characteristic from a stored characteristic in the fixed coefficient storing section, on the basis of an output of the out-band power measuring section; and an amplitude phase change amount computing

section for computing a change amount of amplitude and phase on the basis of outputs of the fixed coefficient storing section and error coefficient computing section, and instructing the amplitude phase control section to carry out 5 the control on the basis of the change amount of amplitude and phase. This enables the adapting operation to follow up the characteristic variation on the power amplifier. Furthermore, as compared to the distortion compensator having only a coefficient computing section requiring to 10 update several tens to several hundreds of memory, it is satisfactory to update several polynomial coefficients representative of an error characteristic. Thus, the number of times of coefficient updates can be greatly reduced.

Also, a distortion compensator of the invention 15 comprises: a variable attenuator for controlling an amplitude of a transmission RF signal; a variable phase unit for controlling a phase on an output of the variable attenuator; a power amplifier for amplifying an output of the variable phase unit; a directional coupler for 20 distributing an output of the power amplifier; a frequency converter for frequency-converting one of outputs of the directional coupler; a Fourier transform section for Fourier-transforming an output of the frequency converter; an out-band power computing section for computing an out- 25 band power from an output of the Fourier transform section; an envelope detecting section for outputting an amplitude value of an envelope on the transmission RF signal; a fixed

coefficient storing section for storing a characteristic reverse to a pre-measured input/output characteristic of the power amplifier; an error coefficient computing section for computing an error characteristic of from a stored 5 characteristic in the fixed coefficient storing section, on the basis of an output of the out-band power measuring section; and an amplitude phase change amount computing section for computing a change amount of amplitude and phase on the basis of outputs of the fixed coefficient storing 10 section and error coefficient computing section, and instructing the variable attenuator and variable phase unit to carry out the control on the basis of the change amount of amplitude and phase. This enables the adapting operation to follow up the characteristic variation on the power 15 amplifier. Furthermore, as compared to the distortion compensator having only a coefficient computing section requiring to update several tens to several hundreds of memory, it is satisfactory to update several polynomial coefficients representative of an error characteristic. 20 Thus, in operation, the number of times of coefficient updates can be greatly reduced.

Also, the error coefficient computing section of the distortion compensator of the invention is to compute a polynomial having, as a variable, an amplitude value of a 25 transmission base-band signal or transmission RF signal, to update a coefficient of the polynomial from the out-band power. Due to this, error coefficient expression can be by

a polynomial having as a variable an amplitude value instead of by a table having as an address an amplitude value, thereby reducing the number of times of updating the adapting operation and shorten the convergence time.

5 Furthermore, because the polynomial coefficient is updated depending upon a characteristic change of the power amplifier, distortion compensation characteristic is available even against the input/output characteristic change to/from power amplifier caused by environmental variation or a request from the communication system.

10 Also, the out-band power computing section of the distortion compensator of the invention has a power computing section for computing an adjacent channel leak power ratio and a determining section for determining whether the adjacent channel leak power ratio is equal to or smaller than a predetermined value or not, to instruct the power amplifier to halt operation when the adjacent channel leak power ratio is greater than the predetermined value. Due to this, monitoring is possible at all times as to whether the transmitter satisfies a given specification or not. In the event of a departure from the specification, the power amplifier is halted in operation. Thus, it is possible to prevent radio wave radiation impedimental to the adjacent channel.

25 As described above, with the present invention, it is possible to reduce the number of times of updating the coefficient for distortion compensation, rapidly converge

the adapting operation to follow up the characteristic fluctuation of a power amplifier and prevent the interference to the adjacent channel due to abnormal distortion on the power amplifier.

5

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a block diagram of an adaptation-type distortion compensator according to embodiment 1 in the present invention.

10 Fig. 2 shows a block diagram of an adaptation-type distortion compensator according to embodiment 2 in the invention.

15 Fig. 3 shows a block diagram of a coefficient computing section according to embodiment 1 and 2 in the invention.

Fig. 4 is a flowchart showing a process to update the coefficient of a polynomial of an error coefficient computing section according to embodiment 1 and 2 of the invention.

20 Fig. 5 shows a block diagram of a conventional non-linear distortion compensator.

Fig. 6 shows a block diagram of a conventional non-linear distortion compensator.

25 BEST MODE FOR CARRYING OUT THE INVENTION

Now embodiments of the resent invention will be explained with using the drawings.

(Embodiment 1)

Fig. 1 is a block diagram of a distortion compensator according to an embodiment of the present invention. An amplitude computing section 102 is to compute an amplitude value 103 of a transmission base-band signal 101. A coefficient computing section 121 is to compute an amplitude coefficient 105 from an amplitude value 103 and phase change amount 108, from an amplitude value 103 and out-band power computing section 119. Herein, the coefficient computing section 121 is explained by using the drawings.

Fig. 3 is a block diagram showing a configuration of the coefficient computing section 121. In Fig. 3, a fixed-coefficient storing section 104 has a memory storing a coefficient for the characteristic reverse to a pre-measured input/output characteristic of a power amplifier 113, to compute a fixed coefficient α on the basis of an amplification value X as a parameter. Meanwhile, the error-coefficient computing section 105 is to compute a low-degree polynomial ($Ax^2 + Bx + C$) for computing an error coefficient β from the amplitude value X . An amplitude-phase change amount computing section 106 is to compute an amplitude change amount (R) 107 and phase change amount (θ) 108, on the basis of a multiplied value of the output of fixed-coefficient storing section 104 and the output of error coefficient computing section 105.

Meanwhile, a delay 109 is to delay a transmission base-band signal by a predetermined time. An amplitude-

phase control section 110 is to control the amplitude and phase of an input signal, according to the amplitude change amount 107 and phase change amount 108. A D/A converter 111 is to convert an input digital signal into an analog signal 5 while an quadrature modulator 112 is to carry out quadrature modulation.

A power amplifier 113 is to amplify the power of an input signal. A directional coupler 114 is to distribute the input signal into two signals while an antenna 115 is to 10 radiate radio waves.

A frequency converter 116 is to down-convert the input signal into an intermediate-frequency band (IF band) or base band. An A/D converter 117 is to convert an input analog signal into a digital signal while a Fourier transform 15 section 118 is to carry out a Fourier transform on the input signal, to output a frequency spectrum.

A out-band power computing section 119 is configured with a power computing section 122 for computing an integration power at an outer frequency range of a 20 transmission modulation signal band and an adjacent-channel leak power ratio and a determining section 123 for determining whether a specification required for the communication system is satisfied or not.

Concerning the fixed-coefficient storing section 104 shown in Fig. 3, there is a method to pre-measure a 25 coefficient for a characteristic reverse to an input/output characteristic of the power amplifier 113 and then store

12

that coefficient in a memory. With this method, it is satisfactory to merely read out the coefficient stored in the memory by the use of an amplitude value 103, outputted from the amplitude computing section 102 as an address, 5 requiring less operation amount. Another realization method is to previously express, in a polynomial form, the characteristic reverse to an input/output characteristic of the power amplifier 113. The degree of polynomial is determined for full approximation to the input/output 10 characteristic of the power amplifier 113. This method, despite requiring polynomial operation, has a merit not requiring a large capacity of memory.

Meanwhile, the error-coefficient computing section 105 is realized by expressing, by a polynomial, an error coefficient for an error between a coefficient stored in the 15 fixed-coefficient storing section 104 and a coefficient for a characteristic reverse to a current input/output characteristic of the power amplifier 113. This error coefficient, varying in time, is updated by adapting 20 operation as hereinafter referred. This configuration, because the error-coefficient computing section 105 satisfactorily expresses an error coefficient, requires a reduced degree of polynomial, e.g. degree 1 to degree 2.

Explanation is made on the operation of the distortion 25 compensator configured as above, by using Figs. 1 and 3. At first, receiving a transmission base-band signal 101, the amplitude computing section 102 outputs an amplitude value

103 thereof. Receiving the amplitude value 103, the fixed-coefficient storing section 104 of the coefficient computing section 121 outputs a fixed coefficient in accordance with the amplitude value 103. Meanwhile, receiving the amplitude 5 value 103 and the integration power from out-band power computing section 119, the error-coefficient computing section 105 computes and outputs an error coefficient corresponding to an error of between a fixed coefficient to be outputted from the fixed-coefficient storing section 104 10 and a coefficient for a characteristic reverse to a current output of the power amplifier 113. This error is representative of a change amount in input/output characteristic of the power amplifier 113 caused by environmental variation such as temperature, power voltage, 15 aging and so on. Receiving the fixed coefficient and the error coefficient, the amplitude-phase change amount computing section 106 outputs an amplitude change amount 107 and phase change amount 108.

Meanwhile, the transmission base-band signal 101 is given a suitable delay amount by the delayer 109, and then 20 inputted to the amplitude-phase control section 110. Herein, the delay given by the delayer 109 is in an amount of processing time on the transmission base-band signal 101 passing the amplitude computing section 102, the fixed-coefficient storing section 104, error-coefficient computing 25 section 105 and the amplitude-phase change amount computing section 106 and reaching the amplitude-phase control section

110. The delayed base-band signal, in the amplitude-phase control section 110, is controlled in amplitude and phase by the utilization of the amplitude change amount 107 and phase change amount 108. The signal controlled in amplitude and 5 phase is converted by the D/A converter 111 into an analog signal, and then up-converted by the quadrature modulator 112 into a desired frequency. The frequency-converted signal is amplified by the power amplifier 113 to a desired power value, thus being turned into a distortion-offset 10 linear signal. This signal is distributed by the directional coupler 114, one of whose output signals is sent out as a radio wave from at antenna 115.

The other output signal of the directional coupler 114 is down-converted by the frequency converter 116 into an 15 intermediate frequency band (IF band) or base band. The down-converted signal is converted by an A/D converter 117 into a digital signal. The Fourier converting section 118 Fourier-converts the converted signal, to output a frequency spectrum. Receiving the frequency spectrum, the out-band 20 power computing section 119 computes an outer frequency range power in a transmission frequency signal band. Herein, the distortion component caused on the power amplifier 113 appears as an out-band frequency component. Accordingly, the amount of a distortion caused on the power 25 amplifier 113 can be known by computing a power through integrating out-band frequency spectrums. Otherwise, an adjacent-channel leak power ratio may be computed by and

15

outputted from the out-band power computing section 119. The adjacent-channel leak power ratio can be determined by computing a ratio of an integration of frequency spectrums in the transmission modulation signal band and an 5 integration of frequency spectrums in the adjacent-channel band.

The integration power outside the transmission modulation signal band is inputted to the error-coefficient computing section 105, whereby the foregoing error 10 coefficient is updated by adapting operation. The error coefficient is updated such that the out-band power value outputted from the out-band power computing section 119 or the adjacent-channel leak power ratio becomes smaller in value.

15 Meanwhile, the error-coefficient expression is realized by a low-degree polynomial, as noted before. The polynomial coefficient is updated by adapting operation based on out-band power.

Now explanation is made on the adapting operation to 20 update the polynomial coefficient.

Fig. 4 is a flowchart showing a process to update, from a frequency spectrum signal, the polynomial coefficient of a polynomial in the error-coefficient computing section.

At first, the power computing section 122 computes an 25 adjacent-channel leak power ratio from a frequency spectrum signal outputted from the Fourier transform section 118 (step S701).

Next, the determining section 123 determines whether the computed adjacent-channel leak current ratio satisfies the specification required in the system or not (step S702). In the case the specification is not satisfied, a control signal for halting the operation is outputted to the power amplifier 113 (step S703).

When the specification is satisfied, the error-coefficient computing section 105 is notified the adjacent-channel leak power ratio. The error-coefficient computing section 105 compares the adjacent-channel leak power ratio with the distortion amount in the preceding time (step S704). In the case of a decrease in distortion, the step vector μ is not changed but set with the same value (step S705), thereby updating the polynomial coefficient (step S706).

Meanwhile, in the case of an increase in distortion, the step vector μ' is multiplied by a predetermined constant γ to thereby change the step vector μ (step S707), and then the process moves to step S706.

The process of the steps S701 to S707 is repeated to thereby update all the coefficients of polynomial. By thus updating the coefficients in the error-coefficient computing section 105, a favorable error compensation characteristic is available even against the input/output characteristic change of the power amplifier 113 due to environmental variation or a request from the communication system. Incidentally, such environmental variation includes

temperature change, aging and so on, while request from the communication system includes carrier frequency change, transmission power change and so on.

As described above, the coefficient computing section 121, for computing a characteristic reverse to an input/output characteristic of a power amplifier, is configured by the fixed-coefficient storing section 104 and the error-coefficient computing section 105. Due to this, as compared to the configuration in which the coefficient computing section makes a computation with one polynomial, update is satisfactorily made to the lower-degree coefficient of polynomial. Consequently, because the number of updates can be reduced, rapid converge is possible on adapting operation.

Meanwhile, in the out-band power computing section 119, the power computing section 122 computes an adjacent-channel leak power ratio from a frequency spectrum as an output signal of the power amplifier 113, while the determining section 123 always determines whether satisfied is a specification required in the system or not. In the case of a determination the power amplifier 113 is faulty and an abnormal signal is outputted, the determining section 123 outputs a control signal 120 to thereby halt the operation of the power amplifier 113. This can prevent the abnormal signal from being sent from the antenna 115.

As described above, when the power amplifier 113 is faulty and distortion occurrence amount is greater than a

18

reference, that fact is detected by the out-band power computing section 119, to output a control signal to the power amplifier 113. This halts the operation of the power amplifier 113, making it possible to prevent radio wave radiation impedimental to the adjacent channel.

5

(Embodiment 2)

Fig. 2 is a block diagram of a distortion compensator in an embodiment of the invention. A directional coupler 10 202 is to distribute a transmission RF signal 201, an envelope detecting section 203 is to output an envelope amplitude 204 of input signal, and an A/D converter 205 is to convert an analog signal into a digital signal.

Meanwhile, a variable attenuator 213 is to control the amplitude of the input signal on the basis of an amplitude change amount 209, which may be a variable amplifier. A variable phase unit 214 is to control the phase of the input signal on the basis of a phase change amount 210. The other configuration is similar to embodiment 1.

20 Explanation is made on the operation of the distortion compensator thus configured, by using Fig. 2. At first, a transmission RF signal 201 is distributed by the directional coupler 202, one of whose output is inputted to the envelope detecting section 203. The envelope detecting section 203 outputs an envelope amplitude value 204. The amplitude value 204 is converted by the A/D converter 205 into a digital signal. The fixed-coefficient storing section 206

25

of the coefficient computing section 223 receives the digital signal and outputs a fixed coefficient in accordance with the amplitude value 204. Meanwhile, the error-coefficient computing section 207 receives the amplitude value 204 and the integration power of from the out-band power computing section 221, whereby the error-coefficient computing section 207 computes and outputs an error coefficient corresponding to an error between a fixed coefficient to be outputted from the fixed-coefficient storing section 206 and a coefficient for a characteristic reverse to a current input/output characteristic of the power amplifier 215. This error is representative of a change amount in input/output characteristic of the power amplifier 215 due to environmental variation, such as temperature, power voltage, aging and the like similarly to the embodiment 1. Receiving the fixed coefficient and the error coefficient, the amplitude-phase change amount computing section 208 outputs an amplitude change amount 209 and phase-change amount 210. The amplitude change amount 209 and phase change amount 210 is converted by the D/A converter 211 into an analog signal to be inputted to the variable attenuator 213 and variable phase unit 214.

Meanwhile, a suitable delay amount is given by the delayer 212 to the other signal distributed by the directional coupler 202. Herein, the delay amount to be given by the delayer 212 is an amount corresponding to a processing time of from the distribution of the transmission

RF signal 201 by the directional coupler 202 to reaching the variable attenuator 213 and variable phase unit 214 through the envelope detecting section 203, the A/D converter 205, the fixed-coefficient storing section 206, error-coefficient computing section 207, the amplitude-phase change amount 5 computing section 208 and the D/A converter 211. The computing section 208 and the D/A converter 211. The delayed transmission RF signal, is amplitude-controlled in the variable attenuator 213 on the basis of an amplitude change amount 209 value. The output of the variable 10 attenuator 213 is inputted to the variable phase unit 214. In the variable phase unit 214, phase control is carried out on the basis of a value of the phase change amount 215. The phase-controlled signal is amplified by the power amplifier 215 to a desired power value, thus being made into a 15 distortion-offset linear signal. This signal is distributed by the directional coupler 216, one of whose output signals is transmitted as a radio wave from the antenna 217.

The other output signal of the directional coupler 216 is down-converted by the frequency converter 218 into an 20 intermediate frequency band (IF band) or base band. After Fourier-transforming the down-converted signal, the process in the out-band power computing section 221, of up to computing an outer frequency range power in transmission 25 modulation signal band is similar to that of embodiment 1. Similarly to embodiment 1, it is possible to know the amount of a distortion caused in the power amplifier 215 by computing a power through integrating out-band frequency

21

spectrums. Furthermore, an adjacent-channel leak power ratio can be determined by computing a ratio of an integration of frequency spectrums in the transmission modulation signal band and an integration of frequency spectrums in the adjacent channel band.

Similarly to embodiment 1, the integration power outside the transmission modulation signal band is inputted to the error-coefficient computing section 105, whereby the error coefficient is updated by adapting operation. Due to this, a favorable distortion compensating characteristic is available even against the input/output characteristic change of the power amplifier 215 due to environmental fluctuation or a request from the communication system.

As described above, by configuring with a fixed-coefficient storing section 206 and error-coefficient computing section 207 a coefficient computing section 223 for computing a characteristic reverse in characteristic to an input/output characteristic to/from a power amplifier, it is satisfactory to update the coefficient in a lower degree of polynomial as compared to the configuration in which the coefficient computing section makes computation with one polynomial. Because this can reduce the number of updates, rapid converging is possible on adapting operation.

Meanwhile, in the out-band power computing section 221, similarly to embodiment 1, the power computing section 224 computes an adjacent-channel leak power ratio from a frequency spectrum which is an output signal of the power

22

amplifier 215 and the determining section 225 always determines whether to satisfy a specification required in the system or not. In the case the power amplifier 215 is faulty and an abnormal signal is outputted, the power amplifier 215 is halted in operation by the control signal 222 from the determining section 225. Accordingly, it is possible to prevent an abnormal signal from being sent from the antenna 217.

The procedure of the above is similar to that of embodiment 1 as shown in Fig. 4. When the power amplifier 215 is faulty and the distortion occurrence amount is greater than a reference, this fact is detected in the out-band power computing section 224 to thereby output a control signal to the power amplifier 215. This halts the operation of the power amplifier 215, thus preventing radio wave radiation impedimental to the adjacent channel.

INDUSTRIAL APPLICABILITY

As in the above, the present invention is useful for a distortion compensator suited for rapidly converging the adapting operation to follow up the characteristic fluctuation of a power amplifier and preventing the interference to the adjacent channel due to abnormal distortion on the power amplifier.

CLAIMS

1. A distortion compensator comprising:
 - an amplitude phase control section for controlling an amplitude and phase of a transmission base-band signal;
 - 5 an quadrature modulating section for orthogonally modulating an output of the amplitude phase control section;
 - a power amplifier for amplifying an output of the quadrature modulating section;
 - 10 a directional coupler for distributing an output of the power amplifier;
 - a frequency converter for frequency-converting one of outputs of the directional coupler;
 - a Fourier transform section for Fourier-transforming an output of the frequency converter;
 - 15 an out-band power computing section for computing an out-band power from an output of the Fourier transform section;
 - an amplitude computing section for computing an amplitude value of the transmission base-band signal;
 - 20 a fixed-coefficient storing section for storing a characteristic reverse to a pre-measured input/output characteristic of the power amplifier;
 - an error coefficient computing section for computing an error characteristic from a stored characteristic in the fixed coefficient storing section, on the basis of an output 25 of the out-band power measuring section; and
 - an amplitude phase change amount computing section for

24

computing a change amount of amplitude and phase on the basis of outputs of the fixed coefficient storing section and the error coefficient computing section, and instructing the amplitude phase control section to carry out the control

5 on the basis of the change amount of amplitude and phase.

2. A distortion compensator comprising:

a variable attenuator for controlling an amplitude of a transmission RF signal;

10 a variable phase unit for controlling a phase on an output of the variable attenuator;

a power amplifier for amplifying an output of the variable phase unit;

15 a directional coupler for distributing an output of the power amplifier;

a frequency converter for frequency-converting one of outputs of the directional coupler;

a Fourier transform section for Fourier-transforming an output of the frequency converter;

20 an out-band power computing section for computing an out-band power from an output of the Fourier transform section;

an envelope detecting section for outputting an amplitude value of an envelope on the transmission RF signal;

25 a fixed coefficient storing section for storing a characteristic reverse to a pre-measured input/output characteristic of the power amplifier;

an error coefficient computing section for computing an error characteristic of from a stored characteristic in the fixed coefficient storing section, on the basis of an output of the out-band power measuring section; and

5 an amplitude phase change amount computing section for computing a change amount of amplitude and phase on the basis of outputs of the fixed coefficient storing section and the error coefficient computing section, and instructing the variable attenuator and the variable phase unit to carry 10 out the control on the basis of the change amount of amplitude and phase.

3. A distortion compensator according to claim 1, wherein the error coefficient computing section is to compute a polynomial having, as a variable, an amplitude 15 value of a transmission base-band signal or transmission RF signal, to update a coefficient of the polynomial from the out-band power.

4. A distortion compensator according to claim 1, wherein the out-band power computing section has a power 20 computing section for computing an adjacent channel leak power ratio and a determining section for determining whether the adjacent channel leak power ratio is equal to or smaller than a predetermined value or not, to instruct the power amplifier to halt operation when the adjacent channel 25 leak power ratio is greater than the predetermined value.

FIG.1

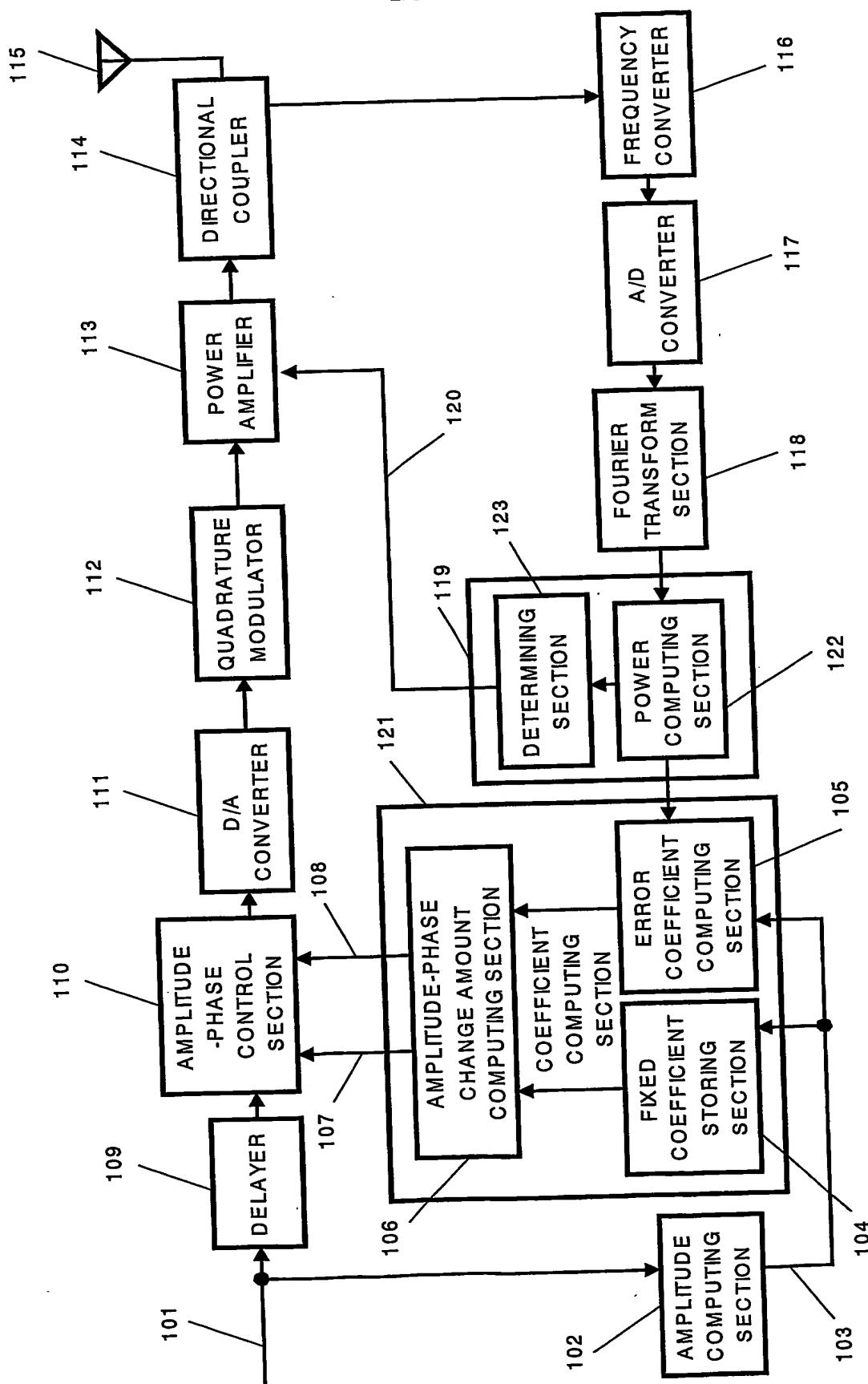


FIG. 2

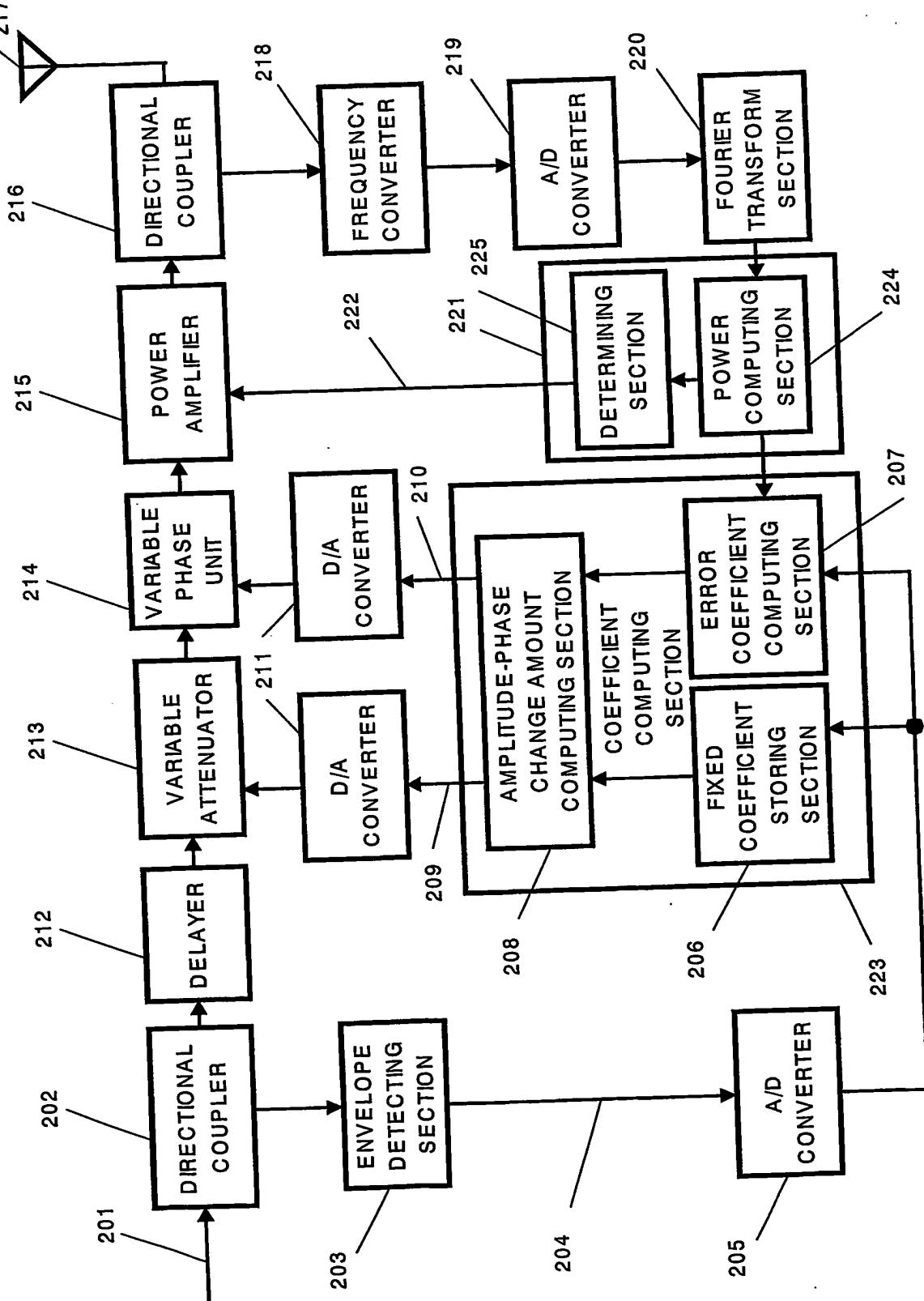
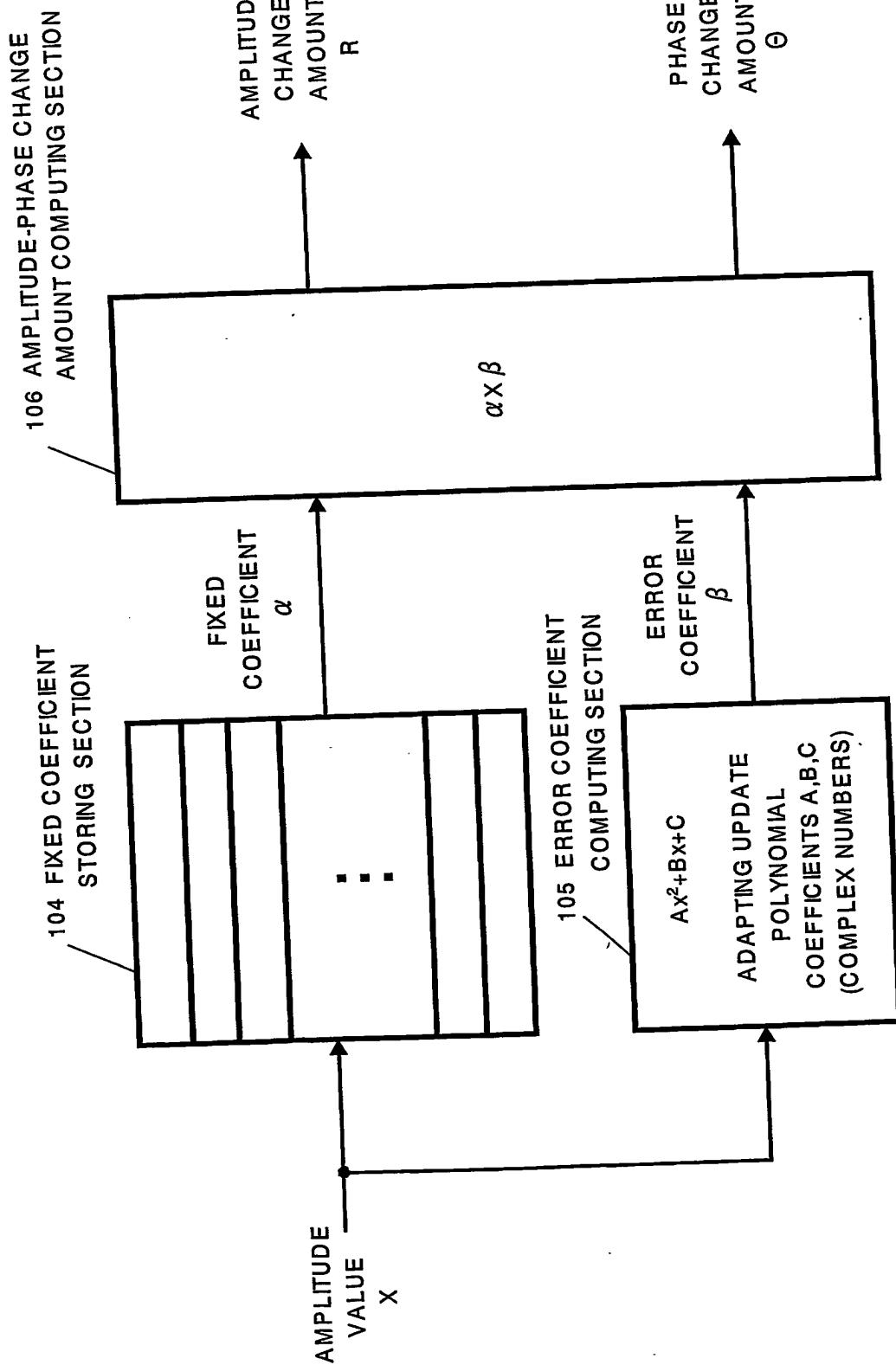
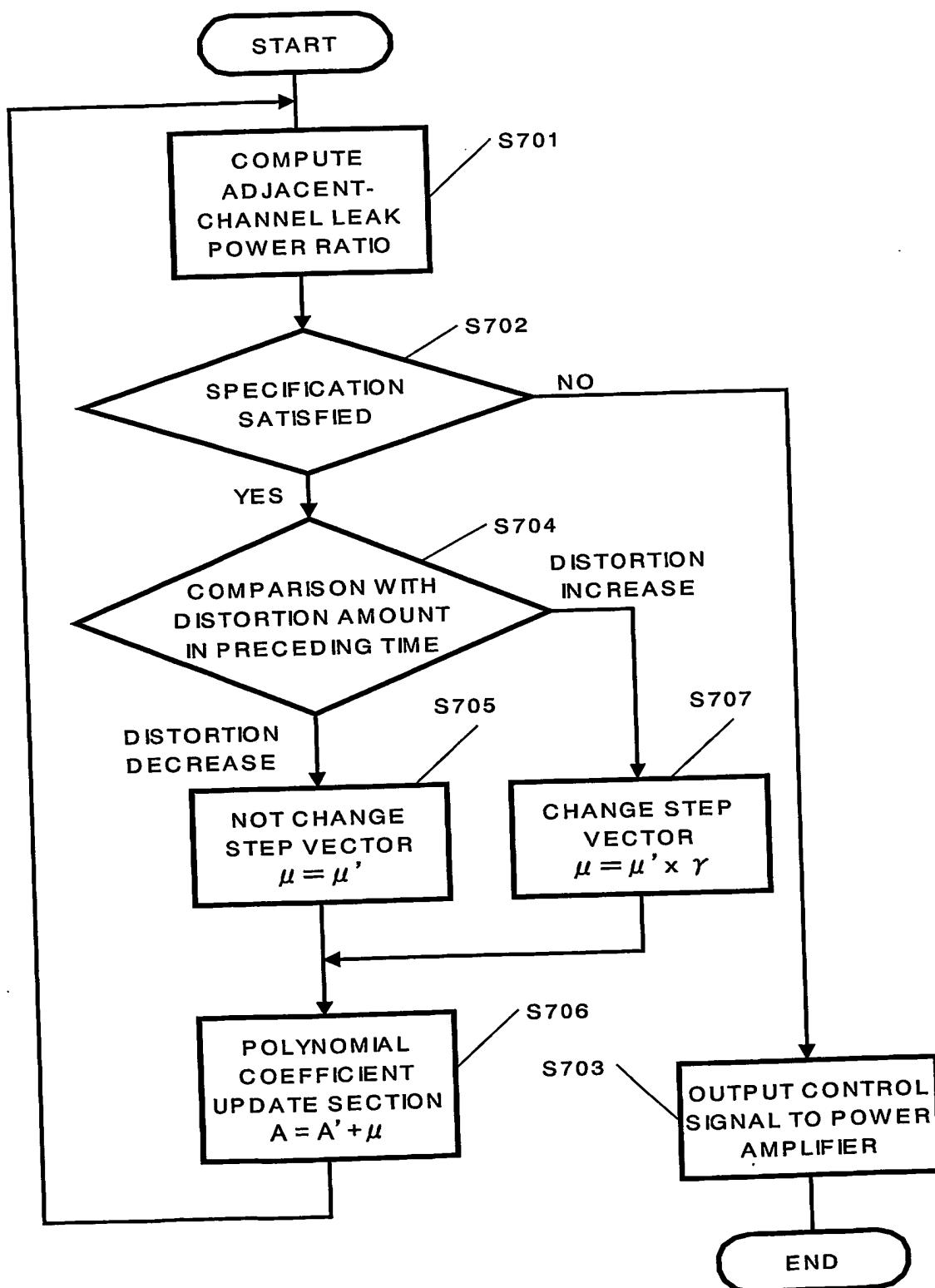


FIG.3



4/9

FIG.4



5/9

FIG.5

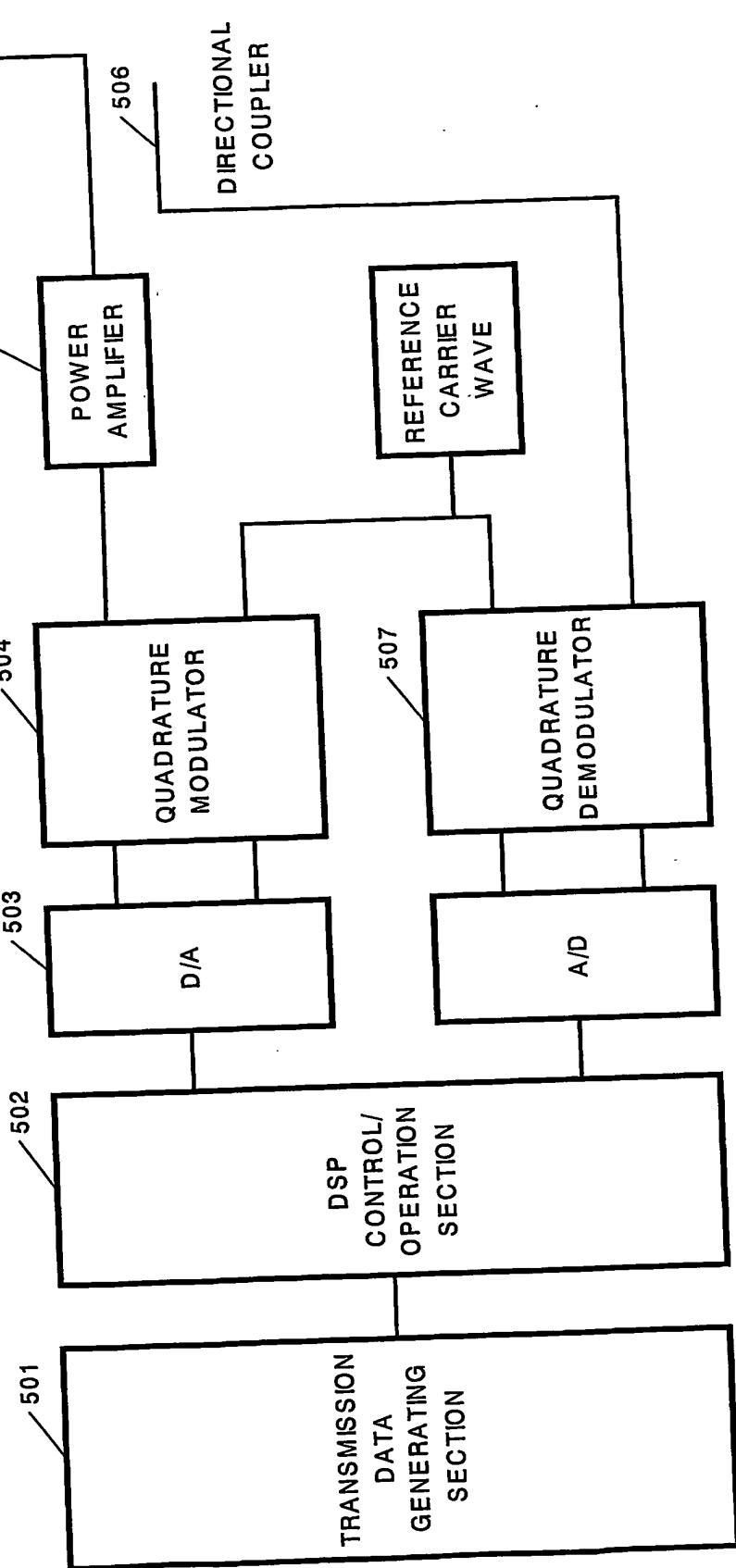
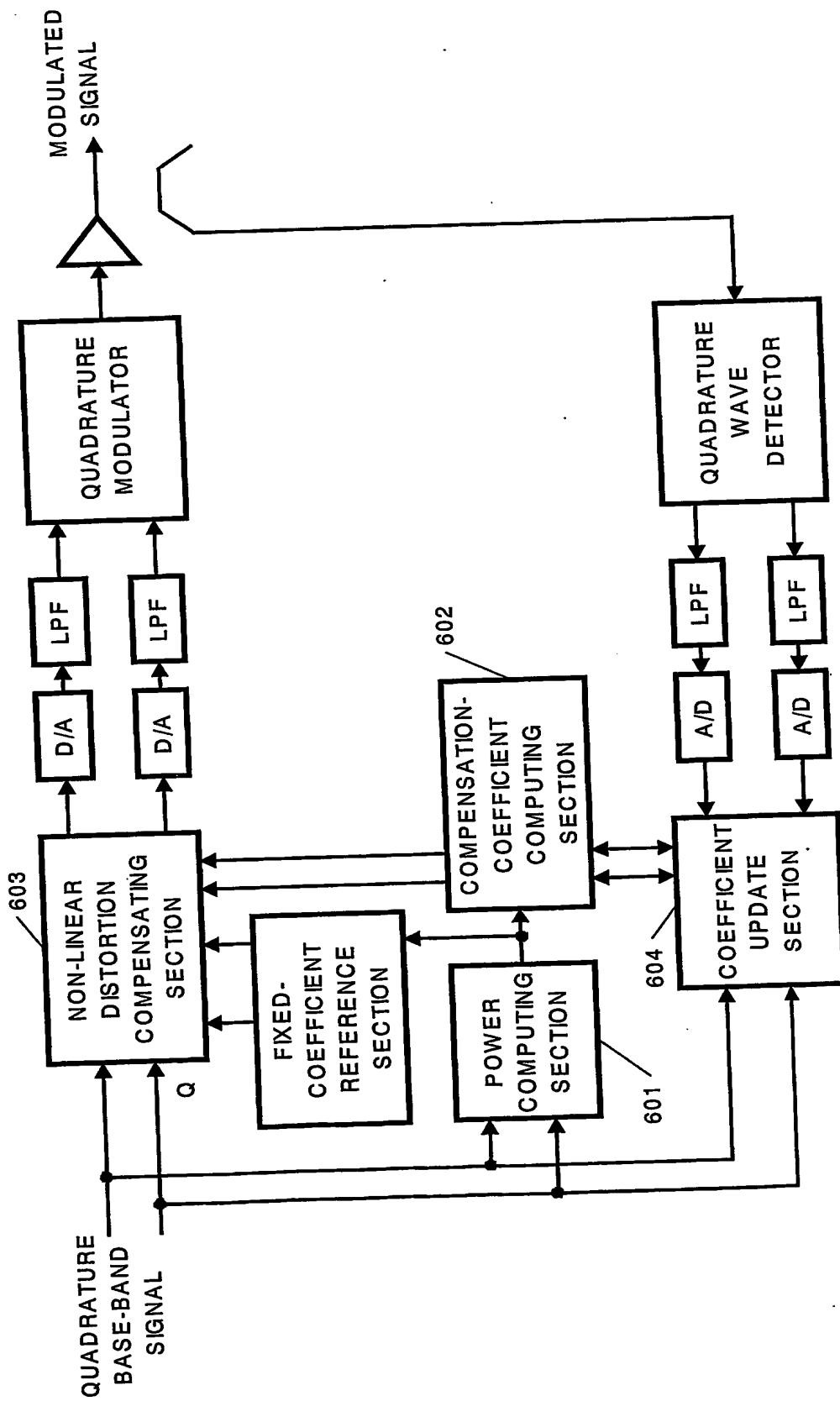


FIG.6



7/9

LIST OF DRAWING REFERENCE NUMBERS

- 101 TRANSMISSION BASE-BAND SIGNAL
102 AMPLITUDE COMPUTING SECTION
103 AMPLITUDE VALUE
104 FIXED COEFFICIENT STORING SECTION
105 ERROR COEFFICIENT COMPUTING SECTION
106 AMPLITUDE-PHASE CHANGE AMOUNT COMPUTING SECTION
107 AMPLITUDE CHANGE AMOUNT
108 PHASE CHANGE AMOUNT
109 DELAYER
110 AMPLITUDE-PHASE CONTROL SECTION
111 D/A CONVERTER
112 QUADRATURE MODULATOR
113 POWER AMPLIFIER
114 DIRECTIONAL COUPLER
115 ANTENNA
116 FREQUENCY CONVERTER
117 A/D CONVERTER
118 FOURIER TRANSFORM SECTION
119 OUT-BAND POWER COMPUTING SECTION
120 CONTROL SIGNAL
121 COEFFICIENT COMPUTING SECTION
122 POWER COMPUTING SECTION
123 DETERMINING SECTION
201 TRANSMISSION RF SIGNAL

- 202 DIRECTIONAL COUPLER
203 ENVELOPE DETECTING SECTION
204 AMPLITUDE VALUE
205 A/D CONVERTER
206 FIXED COEFFICIENT STORING SECTION
207 ERROR COEFFICIENT COMPUTING SECTION
208 AMPLITUDE-PHASE CHANGE AMOUNT COMPUTING SECTION
209 AMPLITUDE CHANGE AMOUNT
210 PHASE CHANGE AMOUNT
211 D/A CONVERTER
212 DELAYER
213 VARIABLE ATTENUATOR
214 VARIABLE PHASE UNIT
215 POWER AMPLIFIER
216 DIRECTIONAL COUPLER
217 ANTENNA
218 FREQUENCY CONVERTER
219 A/D CONVERTER
220 FOURIER TRANSFORM SECTION
221 OUT-BAND POWER COMPUTING SECTION
222 CONTROL SIGNAL
223 COEFFICIENT COMPUTING SECTION
224 POWER COMPUTING SECTION
225 DETERMINING SECTION
501 TRANSMISSION DATA GENERATING SECTION

9/9

- 502 DSP CONTROL/OPERATION SECTION
- 503 D/A CONVERTER
- 504 QUADRATURE MODULATOR
- 504 POWER AMPLIFIER
- 505 DIRECTIONAL COUPLER
- 506 QUADRATURE DEMODULATOR
- 601 POWER COMPUTING SECTION
- 602 COMPENSATION-COEFFICIENT COMPUTING SECTION
- 603 NON-LINEAR DISTORTION COMPENSATING SECTION
- 604 COEFFICIENT UPDATE SECTION

INTERNATIONAL SEARCH REPORT

Rec'd PCT/PCTO 23 JUL 2004

International Application No
PCT/JP 07064

10/502512

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H03F1/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H03F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 400 775 B1 (GOURGUE FR EACUTE D EACUTE RIC ET AL) 4 June 2002 (2002-06-04) claims 2,3; figure 4 ---	1,3
X	WO 00 01065 A (QUALCOMM INC) 6 January 2000 (2000-01-06)	1
A	page 5, line 25 -page 7, last line; figure 2 ---	2-4
A	EP 0 928 062 A (THOMSON CSF) 7 July 1999 (1999-07-07) column 3, line 1 -column 4, line 20; figure 1 ---	1-4 -/-

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

° Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

1 October 2003

09/10/2003

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel: (+31-70) 340-2040, Tx. 31 651 epo nl.
Fax: (+31-70) 340-3016

Authorized officer

Peeters, M

INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP2003/07064

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 236 837 B1 (MIDYA) 22 May 2001 (2001-05-22) column 2, line 60 -column 3, line 56; figure 4 ---	1-4
A	EP 1 193 866 A (FUJITSU LTD) 3 April 2002 (2002-04-03) the whole document ---	1-4
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 11, 30 September 1998 (1998-09-30) & JP 10 150394 A (MATSUSHITA ELECTRIC IND CO LTD), 2 June 1998 (1998-06-02) cited in the application abstract ---	
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 13, 5 February 2001 (2001-02-05) & JP 2000 278190 A (FUJITSU LTD), 6 October 2000 (2000-10-06) cited in the application abstract -----	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/JP 03/07064

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
US 6400775	B1	04-06-2002	FR EP	2773423 A1 0929148 A1		09-07-1999 14-07-1999
WO 0001065	A	06-01-2000	US AU WO	2002101937 A1 4718199 A 0001065 A1		01-08-2002 17-01-2000 06-01-2000
EP 0928062	A	07-07-1999	FR EP	2773281 A1 0928062 A1		02-07-1999 07-07-1999
US 6236837	B1	22-05-2001		NONE		
EP 1193866	A	03-04-2002	WO EP US	0074232 A1 1193866 A1 2002079965 A1		07-12-2000 03-04-2002 27-06-2002
JP 10150394	A	02-06-1998	JP CN EP WO US	3221335 B2 1208528 A 0881807 A1 9823068 A1 2002064236 A1		22-10-2001 17-02-1999 02-12-1998 28-05-1998 30-05-2002
JP 2000278190	A	06-10-2000		NONE		